Integrated Pest Management of Citrus Mealybug[1]

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Abstract

Foliar-applied insecticides and the soil-applied insecticide, Admire, were evaluated for their ability to control citrus mealybug on lemons while having a minimal impact on parasitoids. All of the foliar-applied insecticide exhibited activity towards citrus mealybug. The standard insecticide, Lorsban, performed very well, but since this product is especially harmful to parasitoids it is not considered to have a good fit in IPM programs where parasitoid conservation is emphasized. The currently labeled alternative, Applaud, was an effective treatment and should be considered for citrus mealybug control to avoid destruction of parasitoids. Several experimental insecticides showed promise: NNI-850, NNI-750C and NNI-010. However, NNI-0101 at the lower rate of 0.24 lbs-ai/ac appeared to be weak. The addition of narrow range crop oil, NR-415 at 1.0 gal/ac, appeared to be beneficial for initial mealybug knock-down, especially for the slower acting insecticides such as Applaud. Soil injection of Admire at 16 and 32 oz/ac appeared to have very good activity, but due to variability in the mealybug population, more data should be collected to confirm this finding.

Introduction

Citrus mealybug, *Planococcus citri* is a sporadic pest of citrus, occurring primarily in older, well-shaded groves planted on heavy soils, but can be found infesting citrus on the sandy soils of the Yuma Mesa. They will feed on the roots, bark, foliage, and fruit of citrus. The citrus mealybug injects toxic salvia while extracting plant sap resulting in severe defoliation, fruit discoloration, fruit splitting, and fruit drop. Heavily infested trees will often experience 95% fruit loss and as much as 80% defoliation; making citrus mealybug the most damaging insect pest of Arizona citrus where it occurs. Additionally, the buildup of honeydew and associated sooty mold fungus can also lead to reduced fruit quality and lowered tree vitality though the additional loss of photosynthetic capacity. Damage is most severe in the summer. In addition to being extremely damaging, the citrus mealybug is the most difficult insect pest to control in Arizona citrus.

Currently most citrus mealybug infestations are treated with high rates of Lorsban (chlorpyrifos) or Supracide (methidathion). Citrus mealybugs tend to aggregate on the fruit and cover themselves with a thick layer of mealy wax. Since spray coverage on large fruit is difficult and the citrus mealybug's waxy secretions interfere with spray penetration, control with contact insecticides such as Lorsban and Supracide is difficult. Many growers use high pressure hand-gun sprayers to treat individual trees to alleviate spray coverage and penetration problems, but this procedure is labor intensive and may present worker protection concerns, and control is still often incomplete. Additionally, broad-

[1]The author wishes to thank the Arizona Citrus Research Council for financial support for this project. This is the final report for project 'Integrated Pest Management of Citrus Mealybug'.

spectrum insecticides like Lorsban and Supracide are extremely detrimental to beneficial insects, and one of the best sustainable control agents for citrus mealybug is a parasitic wasp, *Anagraphus* sp.

It would be beneficial if an insecticide treatment could be identified that provides decent control of citrus mealybug while preserving *Anagraphus* sp. so pest resurgence would be lessened. There are several insecticides that may fill this role. Applaud (buprofenzin) is an insect growth regulator that has exhibited activity towards citrus mealybug, and has a negligible impact on parasitic wasps. However, more data is required to determine proper rates and application timing. Another candidate insecticide is Admire (imidacloprid). Admire is a soil-applied systemic insecticide that has demonstrated activity toward whiteflies and aphids. However, its activity on citrus mealybug is not known.

Materials and Methods

These studies were conducted in a block of lemons grown on the Yuma Mesa near Yuma Arizona in 2004. The trees were approximately 15 years of age spaced at 22 ft intervals. Each test was a randomized complete block design with 4 replications. Each plot consisted of a single tree. Sampling was conducted by randomly picking 5 fruit per tree. The number of live citrus mealybug adult females and nymphs were counted on each piece of fruit using a dissecting microscope. Data were collected at 7, 14, 22, 29 and 36 days after treatment (DAT).

Foliar-applied Insecticides

Treatments consisted of an untreated check, Applaud 70WP (buprofezin) at 1.5 and 2.0 lbs-ai/ac, NNI-850 at 0.208 lbs-ai/ac, NNI-750C at 1.6 lbs-ai/ac, NNI-0101 at 0.24 and 0.48 lbs-ai/ac, and the standard, Lorsban 4E (chlorpyrifos) at 3.5 lbs-ai/ac. All treatments included narrow-range horticultural spray oil, NR-415 at 1.0 gal/ac. Applications were triggered based on the appearance of crawlers and eggs near hatching before the trees had become heavily infested. All applications were delivered using a hand-gun sprayer calibrated to deliver 180 gals per acre at 100 psi. All plots were treated on 12 July, 2004.

Soil-injected Insecticide

Treatments consisted of an untreated check, and Admire 2F (imidacloprid) at 16 and 32 fl-oz/ac. Applications were triggered based on the appearance of citrus mealybug in significant numbers but before the trees had become heavily infested. The injection implement consisted of two injection shanks spaced 6 ft apart and with a forward shank to open the furrow. The treatments were injected approximately 8 inches deep at a volume of 9 gal/ac at 20 psi. The shanks were positioned laterally to place the product near the tree's drip line. The applications were made on 27 June 2004.

For both tests, on 20 August, 2004 at first harvest, 15 fruit per plot were sampled and the number with at least one citrus mealybug was counted as infested. From these data, the percentage of infested fruit was calculated for each treatment.

Differences among insecticide treatments for the number of citrus mealybug and the percentage of infested fruit were separated using ANOVA and an F protected LSD, $P \leq 0.05$.

Results and Discussion

Foliar-applied Insecticides

Before the insecticide application, the citrus mealybug population was averaging 112 nymphs and 26 adults per fruit across plots on 10 July, 2004. At this point a majority of colonies were small and the nymphs were in the crawler stage. Additionally, there was not much accumulation of waxy bloom.

At 7 DAT, all of the treatments saw a statistical reduction in nymphs, adults and total citrus mealybugs (Tables 1, 2 and 3). This rapid reduction across all treatments was most likely due to activity of the spray oil. By 14 DAT, there were no detectable differences among treatments primarily due to a great amount in variation which was probably an artifact of

the spray oil and localized population recovery.

At 22 DAT, all of the treatments were expressing activity toward citrus mealybug, but none of the insecticides differed among each other in nymphs, adults, or total citrus mealybugs.

At 29 DAT, this trend continued for nymphs (Table 1) but no differences could be detected from the check for the number of adults (Table 2). At this time, the check was heavily infested, averaging 506 citrus mealybugs per fruit, while all of the insecticides averaged less than 55 per fruit. Lorsban had the fewest citrus mealybugs at 0.60 per fruit, while NNI-0101 at 0.24 lbs-ai had the most mealybugs among the insecticides. The reason we could not detected a difference between Lorsban and NNI-0101 at 0.24 lbs-ai/ac was simply due to variability inherent to the clumped distribution behavior of citrus mealybug.

At 36 DAT, all of the insecticides were still performing well with the exception of NNI-0101 at 0.24 lbs-ai/ac, which did not differ from the check in citrus mealybug nymphs and total mealybugs.

Based on the percentage of citrus mealybug infested fruit near first harvest (Figure 1), all of the treatments were cleaner than the check, but Lorsban, Applaud at 1.5 lbs-ai/ac, NNI-850 and to a lesser extent, NNI-0101 at 0.48 lbs-ai/ac appeared to be slightly superior. However, these data are somewhat misleading since a piece of fruit with just one mealybug was counted as infested. In retrospect, and rating scale of infested fruit at harvest would probably be a better measurement of infestation.

Soil-injected Insecticide

Since this study was initiated when citrus mealybug were not numerous, it was difficult to determine which trees would have sufficient number of citrus mealybug to evaluate and which would not. This resulted in a great deal of variability that resulted in some seemingly large differences among treatments to be statistically insignificant.

Based on citrus mealybug nymphs, differences were detected only on 3 and 10 Aug, when both of the Admire treatment contained fewer citrus mealybugs than the untreated (Figure 2). Adult citrus mealybug counts were similarly variable, with differences being evident only on 19 July and 3 August (Figure 3). On 19 July, Admire at 32 fl-oz/ac contained fewer adult citrus mealybug than the untreated or Admire at 16 fl-oz/ac. On 3 August, both Admire treatments had fewer adult citrus mealybugs than the untreated.

Based on the percentage of citrus mealybug infested fruit near first harvest (Figure 4), both of the Admire treatments were cleaner than the check, but Admire at 32 oz/ac was cleaner than Admire at 16 oz/ac.

Although these data suggest that soil injection of Admire may have activity towards citrus mealybug, because of the variability in this trial, we cannot be certain as to the degree of this activity.

Table 1. Mean number of citrus mealybug nymphs per lemon fruit, Yuma, AZ 2004.

Treatment[1]	Rate lbs-ai/ac	19 Jul (7 DAT)	26 Jul (14 DAT)	3 Aug (22 DAT)	10 Aug (29 DAT)	17 Aug (36 DAT)
Applaud 70WP	1.5	6.89 b	12.50 a	21.74 b	11.50 b	4.28 b
Applaud 70WP	2.0	7.2 b	33.23 a	26.94 b	22.58 b	3.78 b
NNI-850	0.208	49.14 b	16.24 a	41.67 b	8.87 b	5.68 b
NNI-750C	1.6	3.64 b	10.09 a	4.40 b	4.73 b	4.14 b
NNI-0101	0.24	5.33 b	14.17 a	44.31 b	44.08 b	90.80 ab
NNI-0101	0.48	33.09 b	3.01 a	1.10 b	19.31 b	6.28 b
Lorsban 4E	3.5	0.06 b	0.37 a	23.06 b	0.58 b	2.25 b
Untreated	--	172.75 a	168.28 a	130.66 a	439.61 a	231.50 a

Means in a column followed by the same letter are not significantly different based on an F protected LSD ($P > 0.05$).
[1]All insecticide treatments included NR-415 horticultural oil at 1.0 gal/ac.

Table 2. Mean number of citrus mealybug adults per lemon fruit, Yuma, AZ 2004.

Treatment[1]	Rate lbs-ai/ac	19 Jul (7 DAT)	26 Jul (14 DAT)	3 Aug (22 DAT)	10 Aug (29 DAT)	17 Aug (36 DAT)
Applaud 70WP	1.5	2.97 c	2.78 a	3.09 b	1.23 a	1.97 b
Applaud 70WP	2.0	3.48 c	13.61 a	2.80 b	5.94 a	0.05 b
NNI-850	0.208	14.70 bc	3.28 a	5.19 b	1.12 a	0.83 b
NNI-750C	1.6	3.55 c	1.34 a	1.36 b	0.86 a	2.78 b
NNI-0101	0.24	6.39 c	15.03 a	5.33 b	10.47 a	8.69 b
NNI-0101	0.48	22.98 b	7.97 a	11.97 b	2.56 a	2.09 b
Lorsban 4E	3.5	0.11 c	0.08 a	0.17 b	0.00 a	0.58 b
Untreated	--	42.72 a	174.25 a	97.52 a	120.80 a	27.58 a

Means in a column followed by the same letter are not significantly different based on an F protected LSD ($P > 0.05$).
[1]All insecticide treatments included NR-415 horticultural oil at 1.0 gal/ac.

Table 3. Mean number of total citrus mealybug per lemon fruit, Yuma, AZ 2004.

Treatment[1]	Rate lbs-ai/ac	19 Jul (7 DAT)	26 Jul (14 DAT)	3 Aug (22 DAT)	10 Aug (29 DAT)	17 Aug (36 DAT)
Applaud 70WP	1.5	9.86 bc	15.30 a	24.83 b	12.70 b	6.24 b
Applaud 70WP	2.0	11.00 bc	46.80 a	29.74 b	28.50 b	3.83 b
NNI-850	0.208	63.84 b	19.50 a	46.86 b	10.00 b	5.76 b
NNI-750C	1.6	7.19 bc	11.40 a	5.76 b	5.60 b	6.92 b
NNI-0101	0.24	11.72 bc	29.20 a	49.65 b	54.60 b	99.49 ab
NNI-0101	0.48	56.07 bc	11.00 a	35.03 b	21.90 b	8.36 b
Lorsban 4E	3.5	0.17 c	0.50 a	1.28 b	0.60 b	2.83 b
Untreated	--	215.47 a	342.50 a	228.17 a	506.40 a	259.08 a

Means in a column followed by the same letter are not significantly different based on an F protected LSD (P >0.05).
[1]All insecticide treatments included NR-415 horticultural oil at 1.0 gal/ac.

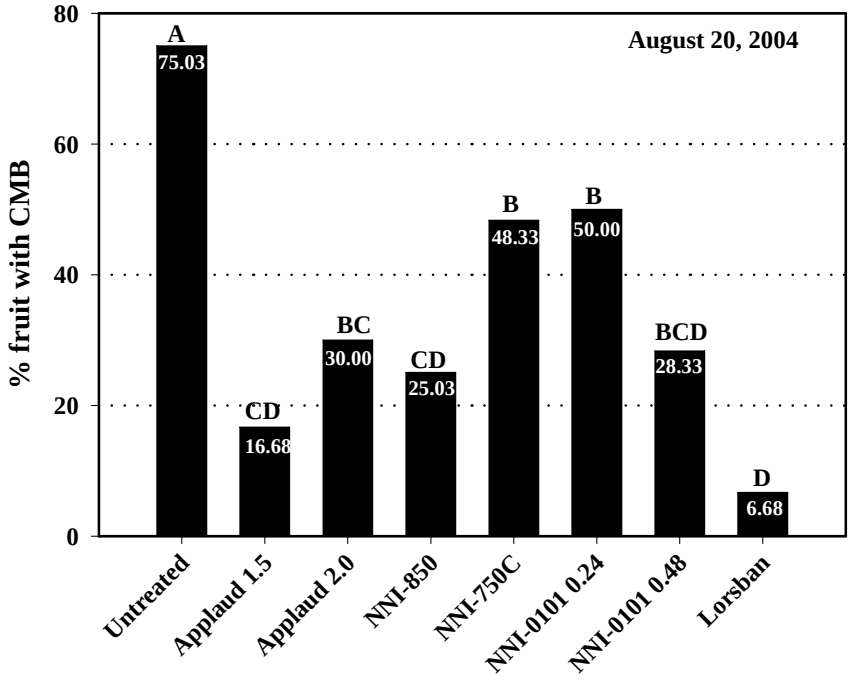

Figure 1. Percentage of fruit with at least one citrus mealybug at 1st harvest.
Bars followed by the same letter are not significantly different, based on an F protected LSD (P > 0.05).

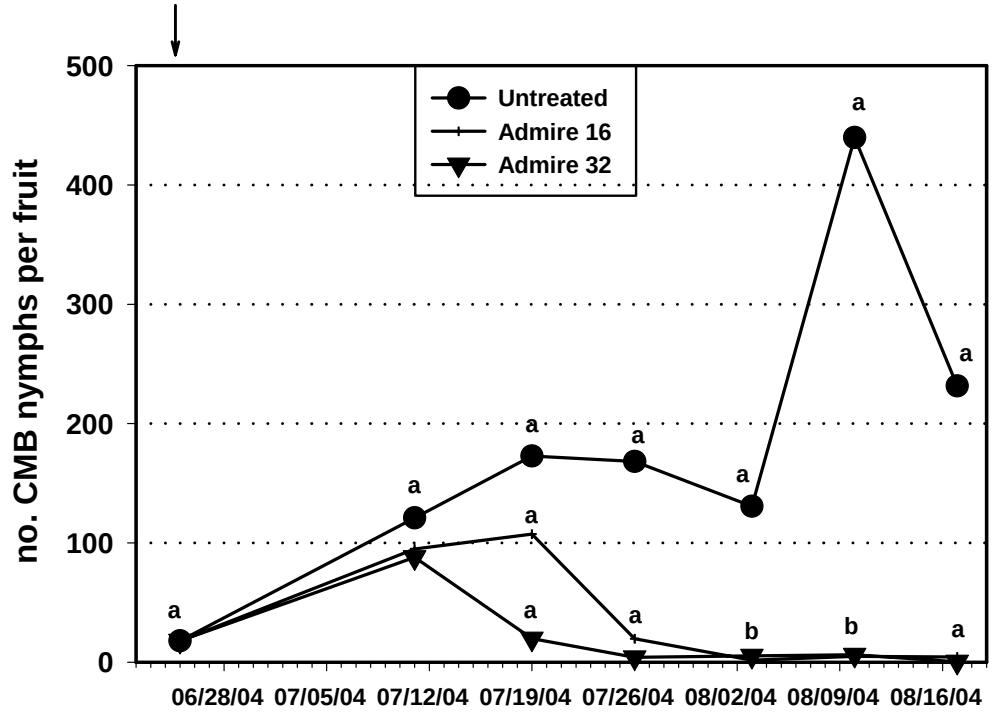

Figure 2. Number on citrus mealbug nymphs per fruit. Points followed by the same letter are not significantly different, based on an F protected LSD ($P > 0.05$).

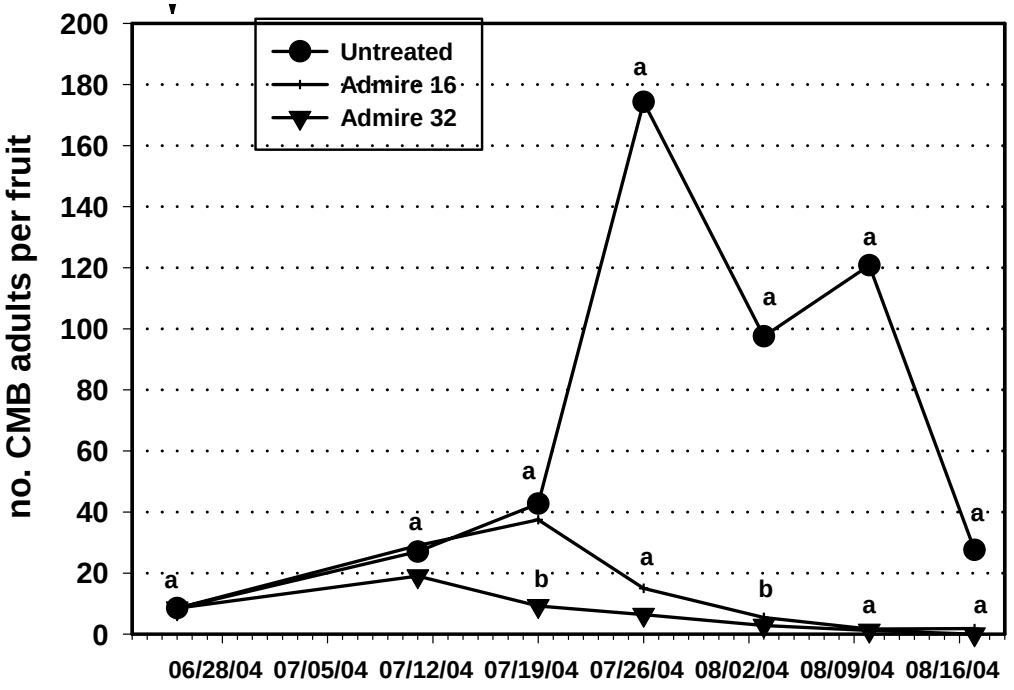

Figure 3. Number on citrus mealybug adults per fruit. Points followed by the same letter are not significantly different, based on an F protected LSD ($P > 0.05$).

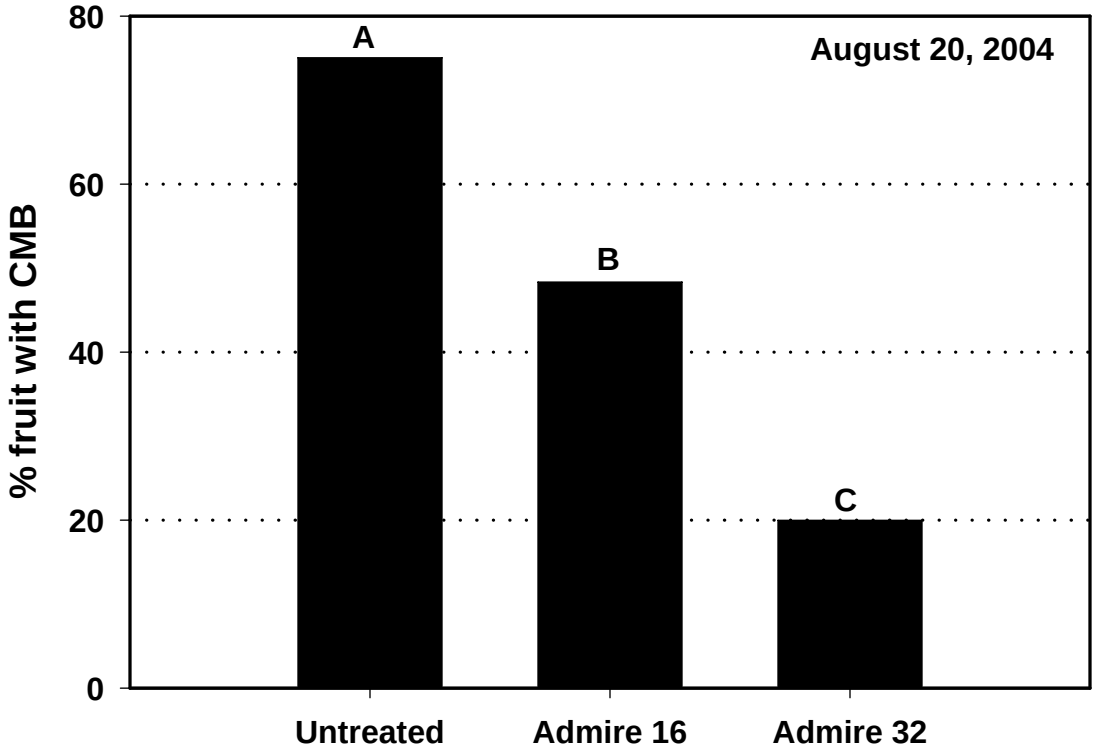

Figure 4. Percentage of fruit with at least one citrus mealybug at 1st harvest.
Bars followed by the same letter are not significantly different, based on an F protected LSD ($P > 0.05$).